

The Concept and Evolution of Zero

K.V. Ramakrishna Rao B.Sc., M.A., A. M. I. E., C. Eng (I)., B.L.,

Introduction: The concept of zero and its related subjects has been very interesting in the history of numbers and mathematics itself, as it is one of the most important technical discoveries in the history of humanity (1). It is surprising to note that most of the so called advanced scientific nations of the world did not have such concept, till it was introduced into their workings. The inventors of Zero, the numerals and the decimal system what we use today, should have applied much thinking in devising such notation and symbolism. Though, Hindus have been credited with for such invention, the books and reference works coming from the Western and Muslim world continue to present different versions throwing shadow of doubt on them. Therefore, it is important to study as to how the inventors were able to invent such a number system, which has been the bedrock of all scientific thinking and thought processes, from which the inventors could be identified scientifically and historically.

The Attitude of Westerners towards Zero: The Westerners themselves have faithfully recorded to accept that in the late twelfth century only, the Europeans actually began to make use of the zero and zero and the decimal system, reportedly introduced to them through Arab traders bringing from India. Though they were having idea about the numbers 1 to 9, they could not understand Zero, as it affected considerably all of their thinking processes. Their concept of Number has been only associated and imbibed with counting, calculation and quantification. Moreover, their calendar had never any zero year, though, they claim that their chronology start from B.C. They considered zero as an intellectual obstacle (2). Without understanding the significance of it, they even opposed the use of it. The resistance to the Indian numerals by those who used the counting board for calculations took two forms. Some considered them as the creation of the Devil, while others made fun and ridiculed them (3).

Arabs / Muslims and Zero: As much credit has been given to the Arabs and Arabs turned Muslim traders for "*their act of taking away Hindu numerals from India to introduce into Europe*", now, some Muslim scholars have even gone to the extent of claiming that the so called Hindu numerals were actually "Arabic numerals" and they were in use even before Hindus invented and zero was also a contribution of Muslims! (4). Under the circumstances, the actual situation has to be assessed to know the truth.

Zero of Babylonians and Mayans: Western scholars have reported that Babylonians and Mesoamericans (Mayans, Incas etc) were using their own zeros, but they were not fully developed in their conceptual and operational meaning in application. As the former used sexagesimal (60 as base) and latter vigesimal (20 as base) systems, and it was not designed for the normal mathematical operations to be consonant with decimal system. Both systems did not contain zero symbol or any symbol to represent zero.

The former used slanted wedge cuneiform and latter dots and lines for 1 to 9 numbers. The higher numbers were represented not by the combination of the basic numbers, but by combined cuneiforms and pictograms. The positional system of number notation was said to have been developed by the Babylonians about 500 or 300 B.C. but, it was with base 60 and not ten, that too in astronomical context. They could only suggest the missing number, not the order of magnitude itself. Therefore, they could write 304, but not 340 or 3400 (5), as they did not have any symbol for zero. Mayans had a symbol a dot inside oval resembling human eye. Moreover, it is not supported by their literature to understand development of logic of numbers and operations. It has been accepted that in the middle of the 13th century, Hindu zero went to China (6). Therefore, mathematically and historically, how the Hindus could have developed such system may have to be analyzed.

Who used Zero First? The earliest usage of zero can be traced back to Pingala in his Chandha-sutra (C.200 BCE) and Panini in his Ashtadhyai (c.500 BCE) (7). But, the philosophical usage of it can be traced back to Vedas (8). The Vedic literature has been very specific that origin of everything has been from "akasa" empty place, one of the words used to denote zero and "Hiranya garba", the golden womb, the place of origin of life in the round shape, obviously to symbolize such concept of emptiness place of origin. As mathematical logic is closely connected philosophy and thought processes, the philosophical aspect has to be taken into account. The first known English use of zero was in 1598.

Words used for Zero and their Significance: The zero is mentioned sunyam, kha and bindhu (9) and also by the words gagana, viyat, akasa, ambara, abhra, anata, vyoma. The word sunya / sunyam is derived from the root sun (p.p), which has the following meanings:

1. born, produced
2. blown, blossomed, opened, budded
3. empty, vacant

Sunanam has the following meanings:

- 1 Bringing forth, parturition
2. A bud, blossom
3. A flower

Shunya as an adjective has the following meanings:

1. empty, void
2. vacant (applied to heart, glances & c), absent listless
3. non-existent
4. lonely, desolate, secluded, deserted
5. dejected, downcast, dis-spirited
6. utterly devoid or deprived of, without, wanting in

7. indifferent
8. guileless
9. non-sensical, unmeaning
10. bare, naked

Sunyam has the following meanings:

1. a vacuum, void, blank
2. the sky, space, atmosphere
3. a cipher, dot
4. non-entity, (absolute) non-existence

Thus, it is evident that the concept of zero is connected with origin of life, universe and number system itself.

Is Zero a Number?: The Zero was not considered as a number in the western world and civilizations until modern times (10). In fact, they were not having the concept of Zero and as well as the Zero connotation, till it was introduced to them, pointed out above. Even in the historical chronology, they were not having any Zero year crossing from B.C to A.D i.e, -5, -4, -3, -2, 0, 1, 2, 3, 4, 5 etc! Many might be surprised to note the lacuna, but it was due to their zero knowledge about Zero only and not to any other reason. Thus, the zero year is absent in the western historical chronology! Then, how they had been so meticulous in recording their chronology?

But, according to Indian system, zero is a number like its Counterpart infinity. It has been used as a number and as well as a value of a variable.

Operations with Zero: The Hindu mathematicians have explained in detail the operations of and with Zero in a unique manner. They are as follows:

- ॐ Aryabhata - I (499)
- ॐ Bhaskara - I (522),
- ॐ Brahmagupta (628)
- ॐ Sridhara (750),
- ॐ Aryabhatta II (Maha-siddhanta, chapter patiganita),
- ॐ Mahavira (Ganita-sara-samgraha 850)
- ॐ Hemachandra (1089)
- ॐ Bhaskara II (1150)
- ॐ Narayana (Patiganita - 1356), and others have clearly explained the following operations in words in their respective works (8).

$$0 + 0 = 0$$

$$0 - 0 = 0$$

$$0 \times 0 = 0$$

$$0 \div 0 = 0$$

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$$\begin{aligned}n + 0 &= n \\ 0 \times 0 &= 0 \\ 0 \div 0 &= \infty\end{aligned}$$

The other operations are:

$$0 \times 0 = 0$$

$$\text{Therefore, } 0 \times 0 \times 0 = 0$$

$$\text{Square root of } 0 \diamond \text{ and cubth root of } 0 = 0.$$

Without zero, there is no operation in algebra. The earliest use of zero in algebra is found in the Brahma-sphuta-siddhanta (rules 31-35, 628 CE). Bhaskaracharya II in his Bijaganita explains the operations under, "Six Rules for Zero". Agni purana mentions 1,582,237,800 in a unique way with decimal place. Recently, scholars have shown that the Indus Valley Civilization used decimal system for all their commercial and construction purposes, implying that such system was in vogue well before 3000 BCE (11).

Some Interesting Questions: About zero and infinity not only mathematicians, but also common man used to think and question different operations. Some intelligent children used to ask the following problems in different ways:

$$\begin{aligned}1 - 1 &= 0 \\ 10 - 10 &= 0 \\ 100 - 100 &= 0, \text{ then all these zeros are equal mathematically?}\end{aligned}$$

Any number is divided by itself is equal to one.
Then, if zero is divided by zero, is it equal to one or zero?

$$0 / 0 = 1 \text{ or } 0?$$

Though Brahmagupta says $0/0 = 0$, Bhaskara II notes that

$$\lim_{w \rightarrow 0} \frac{a.w}{w} = a$$

Is infinity a number? If so, if infinity is divided by is it equal to one or infinity?

$$\infty / \infty = \infty \text{ or } 1$$

Krishna explains as follows:

“.....Thus, if the radius be 120; and the gnomon be 1, 2, 3 or 4; the expression deduced from the proportion, as of sun's altitude is to sine of zenith distance, so is gnomon to shadow, becomes 120/0, 240/0, 360/0 or 480/0. Or, if the gnomon be, as it is usually framed, 12 fingers, and radius be taken as 3438, 120, 100 or 90, the expression will be 41256/0, 1440/0, 1200/0 or 1080/0, which are all infinite" (12).

Numbers without Zero: Without zero, the formation and numbers cannot be thought of. Mathematical thinking could not go beyond 1 to imagine the existence of negative numbers. Square root of any number cannot be found. Thus, the absence of zero or "zero knowledge of zero" hampers all mathematical processes. Therefore, it can be asserted that without zero, there is no mathematical and scientific thinking process leading to any invention. Such invention has to be accepted as important and credit should be given to Hindus without mincing the words.

That Aryabhata (479 CE) could calculate the value of $\pi = 3.1416$ accurately than any other western proclaimed mathematician proves that the zero concept and its operational method had been in existence well before him. Characteristically, he gives the value as follows:

"One hundred and four multiplied by eight with sixty two thousands is the approximate circumference of a circle whose diameter is twenty thousand"
(Aryabhatiyam. II.10, hereinafter as A.B).

So also, the concept of natural numbers, prime numbers, numbers and so on cannot be conceived and understood zero.

Scientific concepts related to Modern Science mentioned elsewhere also could not have evolved all of sudden in 19th and 20th centuries in the west without zero, when their forefathers had been experts in all fields as claimed by the western historiographers of science and technology. They should bring out the truth instead of attributing truth to any particular civilization with bias and prejudice. A co-ordinated multi-disciplinary research study can easily bring out the facts.

The Relation between Zero and Infinity: Mathematically, Zero and Infinity have very close relation, though such relation is difficult to express mathematically for layman to understand. Narayana c.1356 CE in his works mentions about the operations with zero. In English, Greek and western linguistic connotation, zero means nothing, naught, nil, nullum, nonentity, because, it was derived from Arabic "al-sifr cafra = to be empty", but in Indian connotation it is "purnam" i.e, complete. In other words, from which all numbers emanate and end with infinity. Nowhere in this world, such concept exists in any literature, except in Sanskrit literature.

Again, Hindus were first to conceive the concept Of Zero and represent it mathematical operations. While Brahmagupta (628 CE) named it as kha-cheda (the quantity with zero denominator), Bhaskara I I (c.1150 CE) called it as kha-hara (zero as divisor).

"Statement: Dividend 3, Divisor 0. Quotient the fraction 3/0. This fraction, of which the denominator is cipher, is termed an infinite quantity..... In this quantity consisting of that which has cipher for its divisor, there is no alteration, though many may be inserted or extracted; as no change takes place in the infinite and immutable God, at the period of the destruction or creation of worlds, though numerous orders of beings are absorbed or put forth" (13).

Thus, mathematically, according to him, $a/0 = \infty$ and $\infty + a = \infty$.

Ganesa (1545) and Krishna have also noted the operations of infinity.

Both prove $a/0 \pm k = a/0$.

Krishna also shows that $a/0 = b/0$.

$$\infty + 0 = \infty$$

$$0 + \infty = \infty$$

$$\infty \times 0 = 0$$

$$\infty \times \infty = \infty$$

$$\infty + \infty = \infty$$

$$\infty - \infty = 0$$

$$\infty - n = \infty \quad (\text{Bhaskara II})$$

$$\infty / 0 = \infty$$

$$\infty / \infty = 1 \text{ or } \infty ?$$

These operations arrived at by the Hindu mathematicians lucidly with the philosophical basis supported by the Vedic texts.

Hindus had clear distinction between the different usage of the concept of zero. Even in patiganita (arithmetic) the operation of division by zero is not recognized as valid, but treated in Bijaganita (algebra).

Narayana clearly points out the fact:

"Here in patiganita, division by zero is not recognized, and therefore, it is not mentioned here. As it is of use in bijaganita, so I have mentioned division by zero in my bijaganita" (Ganita Kaumudi).

Bhibhutibhusan Datta has dealt with the relation mathematically (14).

The Form of Zero: Bibhutibhusan Datta & Avadhesh Narayan Singh (15), Subash C. Kak (16), Carl B. Boyer (17) and others have opined that the exact form of Zero as used by the Hindus in the earliest time is doubtful, as they employed both dot and round symbols. Kak tried to interpret that the sign might be round oval, but it may be noted that human being may or can write in any way or form according to his habit. We can say that it might also be in the form of ellipses of different axes!

However, the truth is that bindhu is the simple way of representing Zero and round form (other elliptical forms are aberrations of human writing) for mathematical operations.

The bindhu and bindhu written above a semicircle have been characteristically used in many inscriptions and coins to OM, the primordial word and sound of language. Such symbol is also found at the beginning of every ancient written text (palm leaves, scrolls etc). In simpler forms definitely, they can be taken as zero and infinite symbols written together, later theologized to denote Vinayaka, the first person to invent the art of writing and originator of everything. In some places, the dot is placed inside a circle. Therefore, Zero as the origin of number system is supported by the Indian philosophical and mathematical texts.

Formation of Other Numbers from Zero: The pictographic representation of numbers can also be conceptualized and visualized understanding as interpreted below:

0 – for originating containing all numbers. Therefore, it is enclosing and encompassing.

1. single, therefore just a small vertical line. Absolute, can exist independently. The first number to be evolved from zero.

2. Initially two small segmental lines drawn horizontally, obviously to show formed from 1 and inferior to 1. As in due course with fast writing, it attained the present shape.

3. Initially, three small segmental lines drawn horizontally, latter forming into the present shape.

4. Containing four segmental lines, but appearing as three.

5. Formation of five segmental lines together.

6. Formation of six segmental lines together.

7. Formation of two slanting segmental lines representing 2 fours i.e, $4 + 4 = 8$ with one horizontal line on its top implying its subtraction from it to get 7.

8. Formation of two threes written together in opposite direction (mirror image position), by joining two segmental lines. $4 + 4 = 8$ or adding one more line segment to four in the opposite side to get the present shape. Or combination of two zeros implying that it was formed two stages before ten.

9. Zero with one written at its bottom showing, that it was last to originate from zero. This appears to be plausible interpretation in consonance with the Hindu philosophical, cosmological descriptions culled from Puranas.

The numbers and their association with concepts are brought out as follows:

0 - Sunya, kha, gagana, viyat, akasa, ambara, abhra, anata, vyoma

1 - Adi, sasin, indu, kshiti, urvara, dhara, pitamaha, chandra, sitamsu, rupa, rasmi, prithvi, bhu, tanu, soma, nayaka, vasudha, sasanka, kshma, dharani

2 - Yama, aswin, ravichandra, lochana, akshi, dasra, yamala, paksha, netra, bahu, karna, kutumba, kara, drishti

3 - trikala, trijagat, tri, triguna, loka, trigata, pavaka, vaisvanara, dhana, tapan, hutasana, jvalana, agni, vahni, trilochana, trinetra, rama sahadara, sikhin, guna

4 - Veda, samudra, sagara, abdhi, dadhi, dis, jalasya, krita, jala, nidhi, yuga, koshta, bandhu, udhani

5 - Sara, artha, indriya, sayaka, vana, bhuta, ishu, Pandava, tata, ratna, prana, suta, putra, visika, kalamba, margana

6 - Rasa, anga, ritu, masrddha, raga, ari, darsana, tarka, mata, sastra

7 - Aga, naga, parvata, mahidhara, adri, muni, rishi, Atri, svara, chhandas, asva, dhatu, kalatra, saila

8 - Vasu, ahi, gaja, dantin, mangala, naga, bhuti, ibha, sarpa

9 - Go, nanda, ranshra, chhidra, pavana, antara, graha, anka, nidhi, dvara, graham

10 - Dis, asa, kendu, ravanasa, avatara, karma

Zero and Decimal System: The concept of zero only has led to Decimal System. Vedas are the only ancient scriptures to numbers forming the basis of ten. The Yajurveda lists up to 10¹². Agni purana mentions 1,582,237,800 / 158, 22, 37, 800 in a unique manner with decimal places. The Jain works dating back to 500 BCE and the Buddhist work Lalita Vistara (1st cent BCE) mention the usage of decimal system. The people of IVC used decimal system for their commercial and construction purposes as proven by the archaeological evidences, implying that such system was in vogue at least by 3000 BCE.

The Relation between Numbers and Words: The association of numbers with words in Indian mathematical system has been unique one. Aryabhata's the very first verses after his obeisance to God brings out the fact. He explains how the varga letters are used in square places and avarga letters in non-square places in denoting numbers are begun with ka, ya (in places) is equal to the sum of ng and ma (i.e, 5 + 25 = 30); the nine vowels are used in eighteen places both Square and non- square and may be used in higher places after the place (similarly with suitable alternations) (Aryabhatiyam, I.2) Therefore, to understand Indian mathematics and logic, one should have knowledge of Sanskrit also.

The mathematical problems are mentioned as mantras according to metrical scale known as Gayatri with value given to each letter. Therefore, each letter and words formed thereafter should be pronounced accordingly. That is each number and the number combination should be worked out in the prescribed method. If pronunciation is changed, numbers are changed and so also answers. This method clearly proves that mathematical workings were done orally. Only at initial stages, writing was resorted to, by asking children to write on the spread rice or sand, popularly known as aksharabhyaya (the initiation of practice of writing). Once, they were committed to memory, no written record was used. The Arabs have also unwittingly mentioned such numbers "ghobar numbers"!

In his commentary of Talkhis of Ibn Abanna, Abdul Hasan Ali Alkaasadi states:

"These mine signs, called the signs of the ghobar (dust), those that are employed very frequently in our Spanish provinces and in the countries of Maghrib and of Africa. Their origin is said to have been attributed by tradition to a man of Indian nation. This man is said to have taken some fine dust, spread upon a table and taught the people multiplication, division other operations" (18).

Moreover, each letter has pronunciation value with acoustic significance. That is why even ritualized conditions exhibit mathematical significance. In Satapata Brahmana, we note that the yagna vedi construction is related to mantras and in turn with mathematics, as such constructor has to count the number of bricks to construct within a stipulated period (Satapatha Brahmana.X.4.3.19, hereinafter mentioned as S.B). Thus, particular yagna is performed within year or if such yagna is performed, year is completed (S.B.X.5.3.3 and X.2.6.9).

The Basis of such Operations: The basis of operation is explained in theological way and it can be called as Indian Mathematical Logic, like the Modern Mathematical logic dealing with number theory etc. The Upanishad describes OM as follows: "OM. The invisible is the whole, the visible is the whole. From the whole, the visible universe has come out. The whole remains ever itself even though the infinite universe has come out of it". Now let us substitute mathematically OM with zero.

"Zero. The invisible is the whole (represented in form), visible is the whole (represented in symbol form). From whole i.e, zero, the visible numbers have come out. The whole remains ever itself even though the infinite has come out of it (as infinite is also a number)".

Thus, the secret of origin of numbers is succinctly explained in just a small two line verse.

This truth also demolishes the popular theory that script should have evolved first and then speech to assess and determine the material progress of humankind archaeologically. Indians have been proverbially accused of by the western scholars

that they did not have the sense of history, chronology etc., and therefore, they could not write any "history" like "Herodotus" and so on. But, it may be noted that only pompous, grandiose and showy types require such methodology and not the time tested ones.

Calculator is required only for those who cannot calculate manually or rather mentally. Numbers are required only for those cannot convey his mathematics properly. Script is required only for those who cannot express their thoughts properly through speech. Similarly written history is required only for the people who could not preserve their historical consciousness in their historical minds to bring out their historical knowledge anytime historically.

Moreover, in Palmyra manuscripts, the dots and lines are generally drawn with pointed needle as such marks would damage the leaves instantaneously and permanently. Therefore, the customary practice had been not to make such marks, but understood by the scholars. Moreover, such palm leaves would have been taken away by the invading aliens or incoming scholars for its known contents or destroyed by the alien religious groups or deteriorated due to time and negligence of studies without patronage of the rulers. But, whatever inscribed on the stones are available to some extent, in spite of the alien attack and destruction, but based on such evidences, the date of origin of zero and infinity cannot be fixed as 6th and 12th centuries respectively as being done by western scholars (19).

Relying upon the existing inscriptional evidences to assert that Hindus used zero only in the Gwalior inscription dated 876 CE is not only incorrect, but also illogical leading to wrong interpretations and conclusions. This is proved with one example. One Muslim scholar notes,

"It is interesting to note that while the earliest Hindu example of a zero was found on an inscription of 876 AD at Gwalior, the earliest Muslim zero is contained in a manuscript dated 873 AD" (20).

Is it not a wonder that the borrower could use the zero symbol much before the lender! The same scholar claims that ***the first Arabic book containing "Arabic numerals" written in 874 AD, while the first Indian book containing them appeared two years later!*** (21). That is plagiarists were forerunners than the inventors in writing and publishing books! Therefore, it is right time that such apologetic, biased and prejudiced writings should be countered and checked.

From Sunya to Cipher / Zero: The Sanskrit word Sunya was transliterated by the Arabs in 9th century as al-sifr. In 13th century, it was mentioned as cifra in Latin and Zefirum by others. In 14th century, it was mentioned as chiffre in French and zefiro-zero in Latin. In 15th century, it was mentioned as ziffer in German and in French and English. The first known English use of zero was in 1598. Then, can Zero disown Sunya?

Karl Menninger has given comparative tables (22) showing how the numerals were/ have been mentioned and pronounced in different world languages. The table showing the pronunciation of numbers 1 to 10, 20 to 100, 200 to 1000 etc of Kentum languages (Greek, Italic, Celtic, Germanic, Tocharian) and Satem languages (Indian - Sanskrit, Slavic-Old church Slavonic, Baltic-Lithuanian). And anybody can find the very close similarity in the pronunciation indicating that they should have originated from a single source. Then, can all numbers disown the originator?

Therefore, the linguistic approach too points to Indian origin of numbers.

Epistemology of Mathematics: To study the knowledge of mathematics is to study the history of mathematics and the connected people themselves. Mathematical consciousness is more than historical consciousness running through the minds like the pulses of current in every human being. It exhibits not only in the form of number manipulations, but also number related operations i.e, concepts represented by numbers. What is perceived turns into conception and refined and matured conception with strong philosophy and logic leads to associate such thinking processes with vision leading to symbolization to convey it to others. Such symbolization is in both subjective and objective leading to invention.

The Hindu scriptural evidences dating back to 3000 BCE has replete with examples of subjective symbolization of all numbers from zero to infinity with specific names for each. Objective symbolization might have succeeded when the conveyed subjective symbolism was still not perceived, conceived and understood by others. As the objective symbolization exhibited only in perishable objects including inscriptions, absence of such evidences cannot disprove the presence of subjective symbols for numbers. Therefore, the intellectual development should be assessed chronologically before coming to any conclusion.

The so called mouth to mouth propagation of knowledge has never been inferior and it in fact proves the compulsory educational system of the interested and committed. Therefore, when numbers and problems could have been propagated through mouth, the memory power of such people has to be analyzed to appreciate the fact.

Therefore, it is congruous to dub that Indians did not know how to write or write or record their historical events chronologically. How can the History of Hindu mathematics could be a pre- history of Indians, when their numbers were not written by themselves? Without writing, how the mathematical operations were thought of or evolved out of such pre-historic Hindus? How epistemology can be separated from the study of epistemology?

How such Concepts Could have been Evolved?: In modern times, western mathematicians interpret logical way of operations of numbers. Thus, Mathematical logic deals with such concepts, and evolution of operations. But, in Hindu system only, the exact explanations for the use of numbers are found. Therefore, it is evident that as long as one is highly philosophical, they could very well express even big problems only

in descriptive way instead of actually noting down on any paper, board etc as today. Thus, we find copious examples of sums dealt with in Hindu mathematical works. For ordinary mind, it may appear as theological, mythological or obscure, as it does not know the back ground of such concept and formation.

Mythologization of Mathematics through Puranas: The numbers and their association with concepts are brought out as follows:

For numbers 0 to 10, the list has been already given.

- 11- Rudra, Isvara, Mahadeva, akshuhini, labha
- 12 - Surya, arka, aditya. bhanu, masa, sahasramsa, vyaya
- 13 - Viswa, Manmatha, Kamadeva
- 14 - Manu, loka, Indra
- 15 - Tithi, pasha, ahan
- 16 - Ashti, nripa, bhupa, kala
- 17 - Atyashti
- 18 - Dhriti
- 19 - Atidhriti
- 20 Nakha, kriti
- 21 - Utkriti, svarga
- 22 - Jati
- 23 - vikriti
- 24 - gayatri, jina, arhat, siddha etc
- 25- Tattva
- 27 - Nakshatra, udu, bha
- 32 - danta, rada
- 33 - Deva, amara, amara, tridasa, sura etc
- 48 - jagati etc
- 49 - tana etc (23).

The authour has left blank, wherever, he could not find any equivalent expression or interpretation for other numbers.

The mentioning of big number as Padmam (Lotus flower), Maha Padmam (Big Lotus flower) etc has been unique in Hindu notation and such representation is also found in Egyptian pictographics (24).

The association of numbers with theological and philosophical concepts has been evidently done for a purpose, so that children and layman could learn and remember very easily. Thus, we find numerous problems given in the works of Aryabhata, Bhaskara etc., are in the descriptive form instead of representing in numeric form. Thus, not only Mathematical tables were asked memorize in the form of rhyme sung every day, but also certain important formulae. The same method is followed in modern science also. Take the examples of chemical elements and their representation, atomic and molecular structure etc. That is how, even today remnants of the Indian traditional

arts and sciences still survive in the temple architecture and available texts and folk lore only for Indians to revive.

The Relation of Zero with Exact Sciences: Science grows not only based on human necessity, but also depending upon the intellectuality, thus, material progress alone cannot be a measuring stick to decide the scientific advancement of any society. Without zero, can anybody start thinking about the origin Universe, matter, atoms, force, and movement of planets or calculate time, measure earth and so on? Therefore, undoubtedly, the concept zero and its related ideas have led to the development of scientific thought in all fields. Now, some of such consequences are studied.

Zero in Geography and Astronomy: Man measured the land and Space from where he lived and also that of surroundings places. Ruling man had to measure the land of his reign. Thus, dominant and system originating people locate some starting point on for measurement. That the British fixed Greenwich for Mean Time does not mean that measurements of time at other places are unscientific or impossible.

Hindus have such points in their geographical and astronomical measurements. Astronomical works starting with Surya Siddhanta, the ancient extant text, mentions about four cities Lanka, Yavakoti, Siddhappura and Romaka situated on niraksha, the zero degree latitude equally situated at 90 degrees IV. 13-14). Mount Meru is considered as the centre of the earth situated the northern hemisphere (A.B IV.12). It has been the centre/zero point of all geographic, geological and cosmological calculations. The zero degree longitude passes through Ujjaini in India. Thus, for cosmogony, Meru is taken as the centre point, for geography, Lanka and for astronomy Ujjaini (at 20 1/2 degrees latitude north A.B IV. 14).

Zero in Art and Architecture: Zero represented as dot also forms the fundamental block of Art and Sculpture of Hindus. Dot is the simplest form of any figure from which all other figures develop in two and three dimensions. In geometry, it is well known that dot/point is the building block of all figures (lines, angles, triangles, circles etc). Even modern Computer Graphics adapt and adopt the same concept. Art and architecture incorporate all such concepts exhibited through existing temples even today. How dots result in different figures is even proved by common ladies through their kolams (drawn in front of houses everyday in the early morning), which exactly coincide with the oscilloscopic figures displayed. The more dots are in any figure, the more it is clarified.

Zero / bindhu / dot is at the centre of Sri Chakra (drawn in two dimension) and Mount Meru (a three dimensional representation of Chakra) comprise all basic geometrical figures (dots, lines and curves, angles, triangles, polygons and three dimensional figures) forming the fundamental building block of all ground plans and architecture (refer Mansara and other works). The zero has been the fundamental/starting point in all Vedic altar constructions (Satapatha Brahmana - 1500 BCE, Sulva Sutra 800-500 BCE etc). The temple structure stands a proof which incorporates all mathematical concepts from zero to infinity.

Zero and Science: The zero level, zero point, zero state, zero energy, zero gravity, absolute zero, zero angle, zero potential and other concepts are too fundamental in any scientific thought and enquiry and therefore without such concept one should not have developed scientific principles. In fact, all scientifically conceived and depicted building blocks are in dots/circles/globes molecules, atoms, electrons, protons, neutrons and other sub- atomic and nuclear particles. Though, first all particles and planets were assumed to be moving in circular orbits, later, elliptical orbits are ascribed to it purely with mathematical calculations.

Without the concept of zero, there is no explanation for any scientific principle and its origin. Hypotheses and theories of Relativity, Uncertainty, Matter, matter-wave, atoms, molecules, elements, compounds etc have been developed only based on the concept of zero. The original writings of modern scientists are replete with such examples. Now, the computers understand only binary language with two numbers 0 and 1. The Computer graphics too has been developed by pixel (picture element) or point or a single dot. In expounding any hypotheses or theory, only mathematical method is resorted to using the concept of zero and infinity to conclude certain results definitely.

Scientists playing with Zeros: Modern scientific notations, data, datings etc use zeros extensively leading to millions, billions, trillions and so on. In scientific notations, they use milli, micro, nano for smaller numbers and mega, giga for bigger numbers, all in multiples of tens. When infinity becomes unimaginative and it has to be imagined, new words are invented to imagine such unimaginable. Symbolization of myths, thus plays crucial role in science also. Thus, the geologists, archaeologists, nuclear scientists, modern scientists have started using so many zeros for their datings with scientific instruments. But, note, the calculations are done manually i.e, by man by incorporating so many corrections and appending error tables. It is fact that in spite of all scientific achievements and technology, that no two instruments will measure the same quantity to give same number of measure. In fact, there is zero error correction in every instrument or calculation. Thus, they are always so obsessed with zero. An example is given to prove as too scientists were not able to find the temperature of sun, of meddling with zeros! (25).

The Decline for Indian Arts and Sciences: If Hindus were really having such advanced civilization at one time, then, what happened to them? Why such inventors of zero and number system could not have invented anything else afterwards? What were the reasons for such sudden reversal leading to degradation, regression and submission before other invading forces? What went wrong? From the available list of mathematicians and works, it is evident that Indian mathematics flourished up to 14th century and then, there has been decline, definitely with the establishment of Islamic rule in India, the European slow intrusion through missionaries and their occupation as a political power. The Arabs too adapted adopted two pronged strategy in looting India.

We are told that the Arabs as merchants carried away most of the important scientific works and translated into other languages. It is surprising as to why the merchants of commodities should have had interest in Hindu arts and sciences. Particularly, when the

Islam has been theologically against all symbolism, it is not known how they should have indulged in translation of Hindu works into Arabic in the 8th century. Anyway, all of sudden, Europe started attributing everything to Arabians. But, what Arabs as Muslims have done to Indian tradition, culture and heritage is well known to be repeated here.

We find as to how so many temples were destroyed systematically by the Muslim and Christian forces in different parts of India. Here, it is mentioned to high light that by such destruction, not only the places of worship of Hindus were lost, but also many important valuable inscriptions, palm leaves and other works containing ancient knowledge. It has to be mentioned that famous universities like Vikramasila, Valabhi, Odantapuri, Kasi, Dhanya-kantaka, Ujjaini, Taxila, Nalanda, etc were also been razed down by the Islamic forces with all books (or books were taken away to Arabia?). It is also surprising to note while the universities of India were being destroyed, all of sudden universities were coming up in the west after 13th century!

As the Temple and Temple related arts and sciences had decadence due to Islamic onslaught at one side and missionaries smuggling out of Indian works at another side, there were few patrons for such traditions. The British had also enacted Acts and Rules to curtail and ban the traditional industries, which were part and parcel of everyday's life of Indians. Thus, with the enthronement of the British Raj, the traditional system of Indian education was relegated to past. Therefore, is right time that Indians should revive the Indian system education with all modern facilities. Such combined effort will make India to regain its past and lost glory.

Conclusion: In view of the above discussion, the following points are derived as conclusion:

1. Conceptually, the origin of Zero is traced back to Vedic period and it was used by the IVC people.
2. Zero was always considered as number, from which other numbers originated and the decimal system evolved.
3. In the Siddhantic works, it has been specifically mentioned with operations.
4. Its application is found in Philosophy, theology, mathematics, astronomy, art, architecture and other related disciplines.
5. The binary system of Pingala proves its attainment in logical and mathematical operations.
6. Its continuation and usage in culture can be noted in many art forms (Kolams, cloth design, construction etc.)

Notes and References

1. International Encyclopaedia of Communications, Oxford University Press, USA, 1989, Vol.3, p.213.

Peter Barlow (1776-1862) in his New Mathematical and Philosophical Dictionary (1814) says that the discovery of the decimal system with zero, "**.....was perhaps one of the most important steps that has ever been made in mathematics, and does as much honour to its inventor as any other in the history of this science**" (The Encyclopaedia of Americana, Vol.22, p.542, 1969, USA).

2. Karl Menninger, "**Number Words and Number Symbols A Cultural History of Numbers**", The MIT Press, 1967, England, pp.422-424, 428, 438-439.

International Encyclopaedia of Communications, opt.cit, p.213.

John Allen Paulos, the sectional compiler notes that called abacus of any civilization had no zero to count numbers in terms of ten, hampering the discoveries!

3. Karl Menninger, opto.cit., p.422.

An educated French man wrote as late as in the 15th century, "Just as the rag doll wanted to be an eagle, the donkey a lion, and the monkey queen, the cifra put on airs and pretended to be digit".

4. Ali Abdullah Al-Daffa, "**The Muslim Contribution to Mathematics**", Croom Helm Ltd, London, 1977, p.16.

He has even gone to extent of suggesting that, "Muslims offered zero" (Ibid, p.37).

5. Karl Menninger, opt.cit, p.403.

6. Ibid, p.405.

7. Bibhutibhusan Datta & Avadhesh Narayan Singh, "**History of Hindu Mathematics - A Source Book**", Asia Publishing House, Bombay, 1962, p.75.

8. Rig Veda VIII.7-3.1
Yajur Veda XVIII 24 and 25.

9. V.S. Apte, "**English-Sanskrit Dictionary**", Motilal, 1964

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12. H.T. Colebrooke (translation), "Algebra with Arithmetic and Mensuration etc" (Lilavati of Bhaskara II).

15. Bibhutibhusan Datta & Avadhesh Narayan Singh, pt.cit, p.81.

16. Subash C. Kak, **The sign for Zero**, Itihas Darpan, Vol.II, No.1 & 2, New Delhi, 1995.

17. Carl B. Boyer, **Zero: the Symbol, the concept, the Number**, Natinal Mathematical Magazine Vol.18, No.18, May 1994, pp.323-330.

18. Journal Asiatique, I, 1863, p.59fB quoted by B. Dutta and A.N.Singh, opt.cit, pp.99-100.

19. Encyclopedias persistently mention that zero notation was started to be used in India only from 6th / 9th century based on the epigraphical evidence. Some even go to the extent of suggesting the borrowing such knowledge from Babylonians or due to Greek influence, because of the Alexandria.

20. Al Abdullah Al-Daffa, opt.cit, p.37.

21. Ibid, he writes under the title, "Muslims offered zero", p.37.

22. Karl Menninger, opt.cit, pp.92-94.

23. Bibhutibhusan Datta & Avadhesh Narayan Singh, pt.cit, pp.55-56.
A.. C. Burnell, **South Indian Paleography**, Madras.

W. S. Krishnaswamy Naidu, **South Indian chronological Tables**, Government Press, 1889, see Appendix between pages, 93-94.

24. William D. Halsey, **Collier Encyclopedia**, Vol.18, USA, 1980, pp.12-13.

25. Robert Ward, Journal of science, November, 1881.

He, discussing the questions of Heat and Light in the November *Journal of Science*, shows us how utterly ignorant is science about one of the commonest facts of nature – the heat of the sun. He says: – "*The question of the temperature of the sun has been the subject of investigation by many scientists. Newton, one of the first investigators of the problem, tried to determine it, and after him all the scientists who have been occupied with calorimetry have followed his example. All have believed themselves successful, and have formulated their results with great confidence. The*

following, in the chronological order of the publication of the results, are the temperature (in centigrade degrees) found by each of them: Newton, 1,669,300°; Pouillet, 1,461°; Zöllner, 102,200°; Secchi, 5,344,840°; Ericsson, 2,726,700°, Fizeau, 7,500°; Waterston, 9,000,000°; Spoeren, 27,000°; . . . Deville, 9,500°; Soret, 5,801,846°; Vicaire, 1,398°; Violle, 1,500°; Rosetti, 20,000°. The difference is, as 1,400° against 9,000,000°, or no less than 8,998,600°! There probably does not exist in science a more astonishing contradiction than that revealed in these figures."

But science, through the mouth of Mr. Ward, rebukes this as a fallacious theory though still without sufficient data – "*.....it is confidently asserted that the interior of the earth is in a red-hot molten condition, and that it is radiating its heat into space, and so growing colder. One of the results of the Challenger and other explorations of the deep ocean is to determine that the water towards its bottom is freezing cold. Considering that the ocean covers nearly three-fourths of the entire globe, this fact certainly does not support the theory of central heat accompanied by radiation. The coldest water, it is true, usually sinks by its greater weight towards the bottom, and that, it may be said, accounts for its coldness; but, on the theory of radiation the water of the ocean has been for long geological ages supported on the thin crust of the earth, through which the central heat has been constantly escaping, and yet it is still of freezing coldness! Experience would say that the heat cannot have escaped through the water without warming it, because the capacity of water for heat is greater than that of any other substance. We can no more imagine such a radiation, and consequent accumulation of heat in the ocean, without the natural result of a great rise in temperature, than we can believe in a pot resting for hours on a hot fire without the usual result of boiling water. We have no reason, therefore, to believe, as has been suggested, that the earth is growing colder, or that we, in common with all living things, are destined to be frozen out of existence and the earth itself finally swallowed up by the sun.*"